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PROVE THE SUPERIOR ADVANTAGES

OF

RAIL-WAYS

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STEAM CARRIAGES

OVER

CANAL NAVIGATION.

NEW-YORK:
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PREFACE.

The Pamphlet, here reproduced forty years after its first appearance, will now, in the light of its fulfilled and realized speculations, be read with a degree of interest and admiration which, at the period of its publication, it failed to attract.

Having, while recently preparing a paper on the growth of the city of New-York during the last half century, been led into some investigations as to the pioneers in the construction of steamboats and railroads, and remembering something of a pamphlet about railroads, published many years before, by Col. Stevens, of Hoboken, I long sought for a copy of it, and at last, one was found among the bound pamphlets of the New-York Society Library.

Upon being informed of its existence, the sons of the ingenious author obtained permission to have it copied, determining to reprint it in honor of their distinguished father, and they placed the MS. in my hands for that purpose.

It seemed altogether fitting that the direct successors of the publishers, who had given the original to the world, should be invited to print this edition: and accordingly it bears the impress of *Stanford & Swords*, 137 Broadway, 1852, as its original bore that of *T. & J. Swords*, 160 Pearl St., 1812: thus marking at once perpetuity and change.

Of the author of this pamphlet, Col. John Stevens, of Hoboken, a fitting memorial is yet to be written, for he was, emphatically, a benefactor of his country and his race. Born to affluence, his whole life was devoted to experiments, at his own cost, for the common good.

Mr. Stevens was a native of this city, where he was born in the year 1749. His grandfather, John Stevens, a native of England, came to the colony of New-York, in ——, as one of the Law Officers of the Crown. His father, John Stevens, became a resident of New Jersey, and married Elizabeth Alexander, descended from one of the original proprietors of New Jersey, and was himself much in public stations there—and for a time Vice President of the Council.

John Stevens, of whom we are treating, though born in this city, was a Jersey man by residence, and eventually by his marriage with Rachael Cox, daughter of John Cox, of Bloomsbury, N. J., who also

for many years was Vice President of the Council of that State. Mr Stevens himself was for several years Treasurer of the State.

Mr. Stevens' attention was first turned, or rather the bent of his genius was developed and directed, towards mechanics and mechanical philosophy, by the accident of seeing, in 1787, the early, and as now may be said imperfect steamboat of John Fitch, navigating the Delaware river. He was driving in his phaeton on the banks of the river, when the mysterious craft, without sails or oars, passed by; Mr. Stevens' interest was excited—he followed the boat to its landing—familiarized himself with the design and the details of this new and curious combination, and from that hour became a thoroughly excited and unwearied experimenter in the applications of steam to locomotion on the water, and subsequently on the land.

Having been brought, by close family connection, into intimacy with Robt. R. Livingston, (the Chancellor of this State, who married the sister of Col. Stevens,) he induced Mr. L. to join him in these investigations, and they were persevered in at great cost and with little immediate success till Chancellor Livingston, in 1801–2, was sent as minister to France.

So much however was the Chancellor encouraged by the experiments then made, that as early as 1798 he obtained from the Legislature of New-York, an exclusive grant for the use of steam on the waters of New-York. This, however, became forfeit by the failure to avail within the limited time of its privileges.

But previously to the Act of '98 the Legislature of New-York had, as early as 1787, granted successively to *James Rumsey* and to *John Fitch* the exclusive right to navigate the waters of the State with steam propelled vessels; and on 9th January, 1789, John Stevens petitioned the Legislature for a like grant—nothing having resulted from the preceding ones. Mr. Stevens in his petition says that, "to the best of his knowledge and belief, his scheme is altogether new, and does not interfere with the inventions of either of the other gentlemen who have applied to your honorable body for an exclusive right of navigating by means of steam." The petitioner adds that he had "made an exact draught of the different parts of his machine, which, with an explanation thereof, he is ready to exhibit." The prayer of the petition was unsuccessful; but these draughts should be among the papers of the late Col. Stevens, and at this day would be curious.

Mr. Stevens, meanwhile, never renounced his experiments nor despaired of success, and in 1804 he actually constructed a *propeller*, (a

small open boat, worked by steam,) with such decided success that he was encouraged to go on and build the *Phenix*, steamboat, on his own plan and model, and had her ready almost contemporaneously with, but a little after, the first steamboat of Fulton, the *Clermont*. The Clermont entitled Mr. Fulton and Chancellor Livingston, who was co-operating with Fulton, to the benefit of the law, which had been revived by the State of New-York, granting a monopoly of the waters of the State, and thus Mr. Stevens' steamboat was excluded from those waters. On the Delaware, however, and on the Connecticut he placed boats; and his eminent son, Robt. L. Stevens, having embraced his father's views, was now at work with him to improve the known, and invent new resources for accelerated steam conveyance.

In 1812, just before the commencement of the war with England, and when this State was first addressing itself to the thought of connecting the waters of the lakes with those of the ocean by the Hudson, a thought, very rapidly matured in the sequel, by the delays and *now* incredible cost in transporting troops, artillery and munitions during the war from the sea-board to the lakes, Col. Stevens put forth the pamphlet here reproduced, urging that rail-roads and steam-carriages should be preferred to canals and canal boats.

At that day not a *locomotive* existed in the world—and the only railroads were those few, and short *tram-roads*, as they were called in England, connecting for the most part coal mines with canals, or other water transportation, and upon which carriages with the ordinary wheels turning upon their axle-trees were drawn by horses. The carriages were prevented from running off sideways by a flange rising some inches above the outer edge of the flat rail. In this state of knowledge and experience of railroads it was that, in 1812, Col. Stevens made public, in the following pamphlet, his extraordinary and most sagacious views and accurate calculations respecting, not only the feasibility of applying steam to locomotion on land, but the precise mode of such application: its cost, and its almost illimitable advantages. It seems all but impossible to realize the fact, when carefully reading his description of the rail-way, of the locomotive—of its wheels made fast to the axle, and revolving not *on* but *with* it, and held by flanges on the inner periphery, from flying off at a tangent, of a whole train, or "suit," as he calls it, of rail-way carriages, "all firmly attached to each other, and pursuing the same direction:" and of the possible speed they might attain of 40 or 50 miles an hour, but that probably "it would in practice be found convenient not to exceed 20 or 30 miles an hour;" it seems, I re-

peat, almost impossible to realize the fact that, at that day no locomotive existed except in the creative and ingenious mind of the writer; and that no railroad, such as he needed for his unrevealed plan, had ever been laid down.

If he had seen then, what he lived to see afterwards, and from the handiwork and genius mainly of his son Robert on the Camden and Amboy Railroad, the spectacle, ever impressive, however frequently witnessed, of long trains of cars sweeping on with the rapidity of the pigeon's flight, he could not have described with more absolute accuracy all the details of such a train, such a road, and such a locomotive, than is done in the prophetic pamphlet of 1812.

He was treated as a "visionary projector." Time has vindicated his claim to the character of a far-seeing, accurate, and skilful practical Experimentalist and Inventor; and who can estimate, if at that day, acting upon the well considered suggestion of President Madison, "of the signal advantages to be derived to the United States from a general system of internal communication and conveyance," Congress had entertained Col. Stevens' proposals, and after verifying, by actual experiment upon a small scale, the accuracy of his plan, had organized such a "general system of internal communication and conveyance;" who can begin to estimate the inappreciable benefits that would have resulted therefrom to the comfort, the wealth, the power, and above all to the absolutely impregnable union of our great Republic and all its component parts?

All this, too, Col. Stevens embraced in his views; for he was a Statesman as well as an Experimental Philosopher; and whosoever shall attentively read this pamphlet will perceive that the political, financial, commercial and military aspects of this great question were all present to Col. Stevens' mind; and he felt that he was fulfilling a patriotic duty when he placed at the disposal of his native country, these fruits of his genius.

The offering was not accepted. The THINKER was ahead of his age; but it is grateful to know that he lived to see his projects carried out, though not by the government—and that, before he finally in 1838, closed his eyes in death, at the great age of 89, he could justly feel assured that the name of *Stevens*, in his own person and that of his sons, was imperishably enrolled among those which a grateful country will cherish.

I will detain the reader no longer from the pamphlet.

Col. Coll., New-York, May, 1852. CHAS. KING.

INTRODUCTION.

The following documents on a subject calculated, I should suppose, to attract public attention, are committed to the press from an estimation of their importance, and from a conviction of the practicability of the proposed improvement. On a subject of such deep interest to the community at large, I presume no apology will be necessary for the liberty I now take of laying before the public private communications.

Had the subject matter of this publication been exhibited to public view in the shape of an entire and connected essay, written expressly for the purpose, numerous repetitions and inaccuracies, both in style and matter, would not have occurred. But, I am inclined to believe, that the desultory manner in which it is now handled, and the unavoidable repetitions necessarily resulting therefrom, will render it more generally impressive.

Although my proposal has failed to gain the approbation of the Commissioners for the improvement of inland navigation in the State of New-York, yet I feel by no means discouraged respecting the final success of the project. The very objections their committee have brought forward serve only to increase, if possible, my confidence in the superiority of the proposed railways to canals.

So many and so important are the advantages which these States would derive from the general adoption of the pro-

posed railways, that they ought, in my humble opinion, to become an object of primary attention to the national government. The insignificant sum of two or three thousand dollars would be adequate to give the project a fair trial. On the success of this experiment a plan should be digested, "a general system of internal communication and conveyance" adopted, and the necessary surveys made for the extension of these ways in all directions, so as to embrace and unite every section of this extensive empire. It might then, indeed, be truly said, that these States would constitute one family, intimately connected, and held together in indissoluble bonds of union.

Should the national government be induced to make an appropriation to the amount above stated, an experiment could soon be made, either in the vicinity of this city, or at Washington, as may be deemed most expedient.

But the attention of the general government is urged more imperatively to this object, from the consideration of its great national importance in a fiscal point of view. If any reliance can be placed on the calculations I have made, the revenue which this mode of transportation, when brought into general use, would be capable of producing, would far exceed the aggregate amount of duties on foreign importations. However extravagant this position may at first sight appear, I contend it is capable of the strictest demonstration. It is an indisputable fact, that the aggregate amount of internal commerce is vastly greater than that of external commerce.

But one half of the latter, viz., exports, are by the constitution exempted from the payment of duties; the other half, foreign imports only, are subject to the payment of duties.

The far greater part of domestic commerce consists of bulky articles, many of which *now* pay fifty per cent. on

transportation to market. By the introduction of the proposed railways, nine-tenths at least of this enormous tax would in many instances be saved, and the expense of transportation reduced from fifty to five per cent. A toll of five per cent. would raise it to ten per cent. But still the farmer, remotely situated, would save four-fifths of his present expense in the transportation of his produce to market. An average toll, then, of five per cent. would constitute a very moderate impost. But the product of such impost would, at no distant period, be immense. That it would far exceed any amount which could possibly be derived from duties on foreign imports, cannot admit of a doubt.

At a period like the present, when the ordinary sources of revenue no longer continue to pour into the treasury of the United States their tributary streams, and when, too, we are called upon to make "arrangements and exertions for the general security," at such a period, the merits of a system promising, not merely to facilitate most astonishingly "internal communication and conveyance," but to furnish new and abundant sources of revenue, ought surely to command the attention of the general government, and cannot fail to "be seen in the strongest lights."

The extension and completion of the main arteries of such a system of communication would by no means be a work of time. It would be exempted totally from the difficulties, embarrassments, casualties, interruptions, and delays incident to the formation of canals. Requiring no supply of water—no precision and accuracy in leveling, the work could be commenced and carried on in various detached parts; its progress would be rapid, and its completion could be ascertained with certainty. Innumerable ramifications would, from time to time, be extended in every direction. Thus would the sources of private and public wealth, going hand in hand, increase

with a rapidity beyond all parallel. For every shilling contributed towards the revenue, a dollar at least would be put into the hands of individuals.

But there remains another important point of view, in which this improvement demands the attention of the general government. The celerity of communication it would afford with the distant sections of our wide extended empire, is a consideration of the utmost moment. To the rapidity of the motion of a steam carriage on these railways no definite limit can be set. The flying Proas, as they are called by voyagers, belonging to the natives of the islands in the Pacific ocean, are said at times to sail more than twenty miles an hour. Since the resistance of the water to the progress of a vessel increases as the square of her velocity, it is obvious that the power required to propel her must also be increased in the same ratio. Not so with a steam-carriage. As it moves in a fluid 800 times more rare than water, the resistance will be proportionably diminished. Indeed, the principal resistance to its motion arises from friction, which does not even increase in a direct ratio with the velocity of the carriage. If, then, a Proa can be driven by the wind (the propulsive power of which is constantly diminishing, as the velocity of the Proa increases) through so dense a fluid as water, at the rate of twenty miles an hour, I can see nothing to hinder a steam carriage from moving on these ways with a velocity of one hundred miles an hour.*

I will now just observe, that should it be considered an object of sufficient importance, sails might be used whenever the wind was favorable. Van Bram gives a curious account

* This astonishing velocity is considered here as merely possible. It is probable that it may not in practice be convenient to exceed twenty or thirty miles per hour. Actual experiments, however, can alone determine this matter, and I should not be surprised at seeing steam-carriages propelled at the rate of forty or fifty miles an hour.

of the peasantry in the country round Pekin, availing themselves of sails, when the wind favors them, for propelling the wheelbarrows in which their products are carried to markets.

In a military point of view, the advantages resulting from the establishment of these railways and steam-carriages would be incalculable. It would at once render our frontiers on every side invulnerable. Armies could be conveyed in twenty-four hours a greater distance than it would now take them weeks, or perhaps months, to march.

Thus, then, this improvement would afford us prompt and effectual means, not only of guarding against the attacks of foreign enemies, but of expeditiously quelling internal commotions, and thus securing and preserving for ever domestic tranquility.

Whatever constitutional doubts may be entertained respecting the power of Congress to cut and form canals, there can be none about the power to lay out and make roads.

I shall now close this topic with an extract of a message from President Madison to the Senate and House of Representatives of the United States:

"The utility of canal navigation is universally admitted; and it is not less certain, that scarcely any country offers more extensive opportunities for that branch of improvements than the United States; and none, perhaps, inducements equally persuasive, to make the most of them. The particular undertaking contemplated by the State of New-York, which marks an honorable spirit of enterprise, and comprises objects of national, as well as more limited importance, will recal the attention of Congress to the signal advantages to be derived to the United States from a general system of internal communication and conveyance; and suggest to their consideration whatever steps may be proper on their part towards its introduction and accomplishment. As some of

those advantages have an intimate connection with arrangements and exertions for the general security, it is at a period calling for these, that the merits of such a system will be seen in the strongest lights. "JAMES MADISON.

"*Washington*, *Dec.* 2*d*, 1811."

From local circumstances, these rail-ways are calculated to become pre-eminently beneficial to the Southern States. The great predominance of sand, and the deficiency of gravel or stone, precludes the practicability of making good turnpike roads; but the level surface, and great abundance of pine timber throughout this district of country, would not only render the construction of these rail-ways very cheap, but peculiarly advantageous. By preserving nearly a horizontal level, the power requisite for the transportation of heavy bodies would be reduced astonishingly. The cheapness of fuel would reduce too, the expense of supporting this power to almost nothing. Articles would be transported one hundred miles on these ways at less expense than they could now be carried one mile on a deep sandy road. This projected improvement is surely then an object worthy of the most serious attention of the inhabitants of the Southern States. It would at once more than double the value of their products. It appears to me calculated to hold out the most flattering prospects of gain to such enterprising individuals or companies as might be induced to embark a capital in this object.

But, I consider it in every point of view so exclusively an object of national concern, that I shall give no encouragement to private speculations, until it is ascertained that Congress will not be disposed to pay any attention to it.

Should it however be destined to remain unnoticed by the General Government, I must confess I should feel much regret, not so much from personal, as from public considerations. I

am anxious and ambitious that my native country should have the honor of being the first to introduce an improvement of such immense importance to society at large, and should feel the utmost reluctance at being compelled to resort to foreigners in the first instance. As no doubt exists in my mind, but that the value of the improvement would be duly appreciated and carried into immediate effect by trans-Atlantic governments, I have been the more urgent in pressing the subject on the attention of Congress. Whatever then may be its fate, should this appeal be considered obtrusive and unimportant, or from whatever other cause or motive should it be suffered to remain unheeded, I still have the consolation of having performed what I conceive to be a public duty.

JOHN STEVENS.

New-York, May 15, 1812.

DOCUMENTS, &c.

NO. 1.

Copy of a Letter addressed to De Witt Clinton, Esq.

NEW-YORK, *February* 24, 1812.

The Hon. DEWITT CLINTON, Esq.:

Sir—I enclose a memoir addressed to the Commissioners for exploring an inland navigation, &c.

The more I reflect on the plan I have proposed, the more thorough is my conviction, not merely of its practicability, but that it must eventually supercede every other mode of conveyance, where the nature of the country will admit of its introduction. Under such impressions, I consider myself impelled by duty to urge its adoption by the Commissioners. An experiment sufficiently extensive, to ascertain unquestionably its real merits or demerits, could be tried at the expense of two or three thousand dollars.

With sentiments of respect, I am, Sir, your ob't serv't,

JOHN STEVENS.

NO. 2.

Copy of Mr. De Witt Clinton's answer to the above.

ALBANY, *March* 2, 1812.

Dear Sir,—I received your interesting communication addressed to the Commissioners of inland navigation, &c. and shall lay it before the Board at their first meeting.

With my best compliments, I am yours respectfully,

JOHN STEVENS, ESQ. DE WITT CLINTON.

No. 3.

Copy of a Memoir addressed to the Commissioners.

To the Hon., the Commissioners for exploring the route of an Inland Navigation, &c.

The report of the Commissioners appointed by the Legislature of this State, to explore the route of an inland navigation from Hudson River to Lake Ontario and Lake Erie, contains a luminous exposition of the vast importance of facilitating the intercourse between the western country and the tide-waters of Hudson's River.

The plan suggested of bringing the waters of Lake Erie in a Canal, on an inclined plane of three hundred miles in length, to communicate with Hudson's River, is unparalleled for the boldness of its conception, and the grandeur of its object. But the magnitude of such an undertaking must necessarily protract the completion of it to a very distant day, and will have a powerful tendency to make many hesitate respecting the expediency of incurring so heavy an expenditure upon an object presenting so distant a prospect of remuneration.

Still, however, I must concur most heartily with the Commissioners, when they observe, "that no supposable expense can bear an undue proportion to the value of the work. Thus, were it (by giving a loose to fancy) extended to fifty millions of dollars, even that enormous sum does not exceed half the value of what, in all human probability, and at no distant period, will annually be carried along the Canal. The more proper question perhaps is, in what time it can be effected?"

But, independently of the great consumption of time and money incident to so vast an undertaking, there are other circumstances which require serious consideration.

The contemplated route of this Canal lies nearly in an east course from Lake Erie to Albany, and in a high northern latitude, where every thing remains locked up by frost for almost five months during the winter season. Whereas, the southern border of Lake Erie is in a latitude one and a half degree lower, from whence easy communications may be formed with the head waters of the Ohio and the Susquehannah, and but little interrupted by ice.

These routes, it must be confessed, are very circuitous, and the navigation of the natural rivers in their present state, very troublesome and tedious. From the nearest point on Lake Erie, to tide-water on the Delaware, at Philadelphia—on the Chesapeake, at Havre de Grace, or Baltimore, in a straight line—is but a few miles farther than to Albany. But to form a practicable navigation to either of those places by means of Canals, would make a difference of at least an hundred miles in favor of Albany. But as it respects the nature of the ground through which these Canals must pass, there is no comparison; so great and so numerous are the elevations, that the route to Albany is comparatively level. When, in addition to these advantageous circumstances, we take into consideration the decided superiority of the City of New-York, in a commercial point of view, it will not be practicable to divert into another channel the current of trade, when once fairly established from the interior to this city. When, therefore, the immense magnitude of this internal commerce is duly appreciated, every individual inhabitant of this State, but more especially of this city, ought to feel himself interested in the accomplishment of so grand an object.

From the above view of the subject, it appears that there are two considerations of primary importance to be attended to:—first, that this communication with the western country be completed with all possible dispatch; and next, that if practicable, such a mode of effecting the purpose be adopted, as that the travel shall at no time be interrupted.

Without further preface, I will now proceed to propose a plan, which, I flatter myself, embraces both these important objects. Let a railway of timber be formed, by the nearest practicable route, between Lake Erie and Albany. The angle of elevation in no part to exceed one degree, or such an elevation, whatever it may be, as will admit of wheel-carriages to

remain stationary when no power is exerted to impel them forward. This railway, throughout its course, to be supported on pillars raised from three to five or six feet from the surface of the ground. The carriage wheels of cast iron, the rims flat, with projecting flanges, to fit on the surface of the railways. The moving power to be a steam engine, nearly similar in construction to that on board the Juliana, a ferry-boat plying between this city and Hoboken.*

It would be altogether unnecessary to go into a detailed description of the mode of adapting and applying the machinery of a steam-engine to the purpose of propelling carriages placed on railways. It is sufficient to say, that I feel the fullest confidence in being able to convince an experienced and skilful engineer of the entire practicability of the plan.

I shall now attempt to explain the many and important advantages resulting from carrying this plan into effect:

In the first place, as to expense. On the most exaggerated scale of calculation, the expense of such a railway would not exceed that of an ordinary turnpike road, with a good coat of gravel on it.

Second, The far greater part of the work can be performed by common laborers, and as no accuracy of leveling would be

* The steam ferry-boat *Juliana* here referred to was built by Col. Stevens, in 1811. She was an undecked, open boat—sixty-two feet in length, and only twelve feet in breadth, drawing from two and one-half to three feet water. The engine in her was of the model patented by Col. Stevens—having a cylinder of fourteen inches diameter, and two and a half feet stroke, with copper boilers, cylindrical, with flues. The steam was used expansively—cut off in the main valves—as is *now* done in the most approved engines. The *Juliana* attained a speed of seven miles an hour. Mr. Fulton having an interest in the Jersey City ferry, objected to the right of Col. Stevens to run the *Juliana* as a ferry boat between Hoboken and New-York City, as infringing his monopoly from the State of New York, and the *Juliana* was driven off.

She afterwards plied on the Connecticut river between Middletown and Hartford—being the first boat to navigate the Sound, *although undecked*, as Col. Stevens' boat Phenix was the first in 1808, to navigate the ocean, between Sandy Hook and the Delaware.

required, it may be commenced and carried on in as many different places as may be found expedient. It might, therefore, be accomplished with ease in one or two seasons.

Third, From its elevation above the surface of the ground, the timber of which the railway is framed will be little subject to decay; and from this elevation, too, the travel on it can never be interrupted, as it will be raised above the ordinary level of the deepest snows.

Fourth, These railways, from the nature of their construction, will be free from the numerous casualties to which canals are liable.

Fifth, The expense of transportation would be much less than on a canal of the best construction.

To prove this, a summary calculation will be necessary.

The Commissioners inform us (under the authority of Mr. Latrobe), that "by the aid of a railway, one horse would transport eight tons, supposing the angle of ascent not to exceed one degree."

In Nicholson's Journal is an account of one horse transporting for several miles on a railway the enormous weight of fifty tons.

A small steam-engine, then, of ten inches diameter, worked with steam, the elastic power of which was fifty pounds to the circular inch, would possess a power equal to five thousand pounds on the whole area of the piston, moving with a velocity of three feet in a second. This exceeds the power of twenty horses; but one horse, as above stated, can transport on a railway eight tons, and twenty horses would, at the same rate, transport one hundred and sixty tons.

But after making every possible reduction for exaggeration, we may fairly state, in round numbers, that a steam engine, with a cylinder of ten inches diameter, worked on the above principles, would be capable of transporting on a

railway one hundred tons at the rate of four miles per hour. It must be recollected, that Mr. Latrobe's estimate, above stated, is founded on an ascent of one degree. Now, this would give an elevation of ninety-two feet and upwards for every mile. The whole difference of elevation estimated by the Commissioners, between the tide-water at Albany, and the surface of Lake Erie, is five hundred and twenty-five feet.

To gain this ascent, therefore, would require somewhat less than six miles. This bears so small a proportion to the whole distance, that it would be but in a trifling degree erroneous to consider the whole distance as one level. This would much more than compensate for an increase of the rate of velocity in the steam-carriage, from two and a half miles to four miles an hour, especially when we advert to the well authenticated experiment above stated, viz., that a horse is capable of transporting more than fifty tons on a level railway, whereas the above is founded on an estimate of only five tons to each horse.

We will now proceed to estimate the expense per ton of this mode of transportation.

The steam-engine of the above mentioned size would require about a cord of wood to keep it constantly going for the whole twenty-four hours; but to silence all cavil, we will state the consumption of wood at three cords a day. Wood, at an average throughout the whole distance, may be procured for one dollar a cord, but we will estimate it at two dollars a cord.

To attend the fire, and perform any other services that may be required, we will allow four men, at one dollar each per day, is four dollars; which, added to the cost of three cords of wood, would make ten dollars a day. The whole distance, then, of two hundred and eighty miles, from Lake

Erie to Albany, would be traveled in three days. Say the back load would average only one-third of a full freight, there would then remain five days at ten dollars a day, amounting to fifty dollars, for the expense of transporting one hundred tons of produce a distance of two hundred and eighty miles, which is at the rate of fifty cents per ton. But the Commissioners have estimated the expense of transportation through the contemplated canal, from Lake Erie to Hudson's River, at three dollars per ton.

In the above calculation, interest on the capital expended, wear and tear, and repair of machinery, carriages, railways, &c., and no doubt many other incidental charges, are not included. But were we even to double the rate of transportation, raising it from fifty cents to one dollar per ton, still it would amount to only one-third of what the Commissioners have stated as above. But if the construction of railways would require only about one-fourth of the capital estimated for a canal, and the transportation thereon could be afforded at one dollar per ton, instead of three dollars, it is easy to see what an immense revenue the State might derive from toll, and still permit transportation to be performed for much less than it could be done by a canal.

But here I expect to be encountered at the very threshold —to be stigmatized as a visionary projector. Have not, it will be said, steam-engines and railways been long in use in England? And should it be practicable to apply them to such immense advantage in the improvement of transportation, would it not have been done in that country long ago? To this *argumentum ad hominem*, thanks to the enterprise and active genius of our citizens, we are now furnished with ready and conclusive answers. Mr. Latrobe, in a memoir published in the third volume of the Transactions of the American Philosophical Society, animadverting on the projects "for pro-

pelling boats by steam-engines," uses these remarkable expressions: "A sort of mania began to prevail, which indeed has not yet entirely subsided." It is surely unnecessary to say, that in despite of the formidable objections (no less than six) he has urged, "from which," as he tells us, "no particular mode of application can be free," in despite of these anathemas, the project, as we all with pleasure can testify, has completely succeeded. Another gentleman, in the American Medical and Philosophical Register for April 1811, has given a demonstration to prove, that a small obstacle would be sufficient to stop a carriage impelled by a steam-engine. That on roads perfectly hard and smooth it could not ascend an inclined plane of seven or eight degrees; and concludes by saying, that "in whatever point of view we place this subject, we shall be more and more convinced of its futility." He, however, in another place expresses himself as follows: "If roads were perfectly hard, smooth and level, such an engine would probably have the advantage over common carriages, because a small power continually exerted would give a degree of velocity that could not be supported by horses." This admission is amply sufficient to defend the plan now proposed against the force of his demonstration, and renders it unnecessary to go into any investigation to point out its defects. If, then, notwithstanding the host of objections "from which no particular plan can be free," the steam-engine has been successfully applied to propelling boats, we surely need not despair of applying it with success also to propelling carriages. But surely the mere novelty and magnitude of the proposed improvement ought not to startle us. We are too apt to look up with reverential awe to what has usually been called the mother country, for every improvement in the arts, without considering how recent has been the introduction and establishment of these arts in that very country.

It is about a century ago that the first crude attempts to apply the power of steam to useful purposes were made; and it is, as it were, but yesterday that the Duke of Bridgewater first introduced canals, which have since been so astonishingly multiplied in that country. And as to railways, they are of a much more recent date, and are at present very limited in their use and application. A project, therefore, promising such vast improvement in the transportation of commodities to and from the interior of our country, if not stamped with absurdity on the very face of it, surely merits the most serious consideration; and on this occasion I have every reason to felicitate myself on my good fortune.

When I reflect on the high standing in society, and enlightened patriotism of the gentlemen who are, in the first instance, to pass judgment on the plan I have proposed, I feel perfectly satisfied that its real merits, whatever they may be, will be duly appreciated.

It may be objected, that although the elevation of the railways may secure them, in a great measure, from decay, yet the constant transit of the wheels over them will very soon wear them out, in like manner as we see happens to the plank on bridges. But the cases are by no means similar. As the plank on bridges are laid crossways, the warping of the plank, and the enlargement of the cracks or seams between each, causes inequalities in the surface; this produces more or less jolting in the motion of the wheels of carriages passing over. But what tends still more to wear away the plank, are the heads of the nails in the tire of the wheels, and also the nails and calks in the horse-shoes; whereas the surfaces of both the railways, and the rims of the carriage-wheels, are made, in the first instance, perfectly smooth, and free from all inequalities of surface; and as the rims of the wheels will always continue so, the railways can never be affected

by anything except mere pressure. I should presume, therefore, that they will be but little subject to wear. But wherever this wear takes place, they can be renewed again at a trifling expense. But should, contrary to expectation, experience prove these railways to be so subject to wear, as that the frequency of their renewal becomes inconvenient and expensive, recourse could be had at any time to cast or plated iron railways, which, without any further trouble and expense, could be fastened on the top of the wooden railways.

I would beg leave to suggest, that an experiment, by which the real value of the plan now proposed might be completely and satisfactorily ascertained, could be made for a few thousand dollars.

As the power of the engine is expended principally in overcoming friction, which is increased in but a small degree by an increase of velocity, and may be removed almost entirely by using friction wheels, a carriage may be made, by a small increase of power, to acquire a velocity far greater than could be given by the fleetest horses; and as, too, the railways must be incomparably better than the best turnpike road could possibly be made, I am by no means prepared to say what limits may be set to the rapidity with which a carriage may be driven on these ways.

JOHN STEVENS.

New-York, Feb. 24, 1812.

No. 4.

Extract of a Letter from Robert R. Livingston, Esq.

ALBANY, *March 11th*, 1812.

Dear Sir—I did not till yesterday receive yours of the 25th of February; where it has loitered on the road I am at a loss to say. I had before read your very ingenious propositions as

to the railway communication. I fear, however, on mature reflection, that they will be liable to serious objections, and ultimately more expensive than a canal. They must be double, so as to prevent the danger of two such heavy bodies meeting. The walls on which they are placed must at least be four feet below the surface, and three above, and must be clamped with iron, and even then would hardly sustain so heavy a weight as you propose moving at the rate of four miles an hour on wheels. As to wood, it would not last a week: they must be covered with iron, and that, too, very thick and strong. The means of stopping these heavy carriages without a great shock, and of preventing them from running upon each other (for there would be many on the road at once), would be very difficult. In case of accidental stops, or the necessary stops to take wood and water, &c. many accidents would happen. The carriage of condensing water would be very troublesome. Upon the whole, I fear the expense would be much greater than that of canals, without being so convenient.

No. 5.

Answer to Robert R. Livingston's Objections.

NEW-YORK, *March* 16, 1812.

Dear Sir—Yours of the 11th inst. I have just now received, and as you probably will not remain in Albany until this letter reaches that place, I have directed it to Mr. G. Morris, that the Commissioners may be duly apprized of the answers I shall give to your objections against the proposed railways.

"I fear," you say, "the expense would be much greater than that of canals." I have in my memoir stated the expense of the railways at one-fourth of that of a canal; and, for the reasons I shall now assign, I am now convinced the differ-

ence of expense between them will be much greater, if wood only is used.

The Commissioners have estimated the expense of excavating a canal fifteen yards wide, and three feet deep, "at $1,500,000, drawn through a favorable soil lying conveniently, without the opposition of rocks or other impediments. Many of these, however, must be expected, and perhaps double that sum."

Thus, then, the cost of the canal merely is estimated by the Commissioners at $3,000,000. "If the locks be put at $1,500,000, it is the lowest rate that can prudently be supposed. It would, indeed, be safer to set them at two millions."

Not one shilling of this aggregate sum of five millions would be required in the erection of railways. "There will still remain for aqueducts, embankments and mounds a considerable expenditure," and "it is believed that one million of dollars would provide for everything of this sort." Nearly one-half of this sum would be required in constructing a mound over the Cayuga Lake, one hundred and thirty feet high, sixty feet wide at top, with a base of one hundred and ninety feet at bottom, whereas the railways would not require a mound at this place of one-tenth part of this magnitude, and so in proportion throughout the whole distance. We will, however, estimate the necessary embankments, mounds, &c. (aqueducts none would be wanted) at half a million of dollars. There now remains, then, the cost of the railways to be calculated. I shall, in the first instance, suppose the whole to be constructed of wood. Calculating timber at New-York price of twelve and a half cents per cubic foot, four rails, then, of six inches wide, by twelve inches deep, would make two cubic feet, or twenty-five cents a foot running measure, equal to $1320 per mile. The posts or pillars, say eight feet

long, at twenty-five cents a piece, twelve feet apart, four rows would be one dollar for every twelve feet, or $440 per mile. Digging holes, setting posts, braces, and carpenter work, $740. Total $2500 per mile, or $750,000 for the whole distance of three hundred miles. This sum of $750,000 added to $500,000, estimated for embankments, mounds, &c. makes an aggregate sum of $1,250,000 for the whole expense of the railways. And should they even require to be totally renewed once in every ten years, still a capital of $1,500,000, or double the sum of $750,000, would be more than adequate to the purpose.

For the reasons already assigned in the memoir, these wooden ways must be much more durable than the plank on a bridge; and I must confess I do not perceive on what grounds you found your assertion, when you say that they would not last a week.

But were we to admit the absolute necessity, in the first instance, of shoeing these railways with iron, the whole expense of them would fall far short of the cost of a canal. For this purpose I should prefer plate iron of about an eighth of an inch thick. Such plates, I presume, might be procured for twelve and a half cents per pound, at which rate the shoeing four rails would cost somewhat less than $4000 per mile, or $1,200,000 for the whole distance. Should, however, cast iron be preferred, plates of an inch thick would cost for the whole distance about $3,000,000.

These plates, provided they remained unaffected by frost, would last an age, and, by protecting the wooden ways from the effects of the weather, will render them also very durable.

One manifest advantage would, however, attend the adoption of these railways: we would be able to count the cost of the undertaking with sufficient accuracy before the business was commenced, whereas the cost of a canal is, in a great

measure, conjectural, and may, at all events, be estimated at more than double the sum calculated upon by the Commissioners.

But, after all, I must beg leave to refer once more to the very judicious observations of the Commissioners on the subject of expense. "No supposable expense can bear an undue proportion to the value of the work. Thus, were it (by giving a loose to fancy) extended to fifty millions of dollars, even that enormous sum does not exceed half the value of what, in all human probability, and at no distant period, will annually be carried along the canal. The more proper question, perhaps, is, in what *time* can it be effected?"

Were I not thoroughly convinced of the many superior advantages of the proposed railways over canals, the mere saving of expense would not alone induce me to press their adoption. But were railways to cost fifty millions of dollars, whilst a canal could be completed for five, yet, if there is any truth in my calculations, still the railways would ultimately prove the cheapest. Two-thirds of the expense of transportation would be saved, by substituting railways in the place of a canal. The period is not far distant, then, when the annual amount of this saving would be equal to legal interest on a capital of fifty millions, even should the calculation be founded on the supposition, that the increase of population in the western country should in future be in no greater ratio than what it has been for the last ten years. But the increase of population will most assuredly be in a much greater ratio, more especially should these railways be speedily completed.

When you say that a thick stone wall, "clamped with ro n, could hardly sustain so heavy a weight, moving at the rate of four miles an hour on wheels," you appear to have formed an erroneous idea of the distribution of the weight.

One hundred tons placed on four wheels would indeed be a very "heavy weight," but it is not contemplated to put more than one ton on four wheels, or certainly not more than two tons, which would be only five hundred, or, at most, one thousand pounds on each wheel. So moderate a weight could surely have little or no tendency to crush down the ways, and the quicker the passage of the wheels over, then the less would be this tendency.

But I am surprised that you should consider canals as being more convenient than the proposed railways. I must own that I am not able to perceive that canals, in this respect, have in any one particular a preference over them; but, on the contrary, they have in many respects a preference over canals.

In the first place, as there are no locks to pass through, and separate ways for the up and down transit, there can never be any interruptions or detentions. And every one, whether he is induced to travel either by business or pleasure, can calculate with certainty and precision when he will arrive at the end of his journey; I may, indeed say, with almost absolute certainty; for it must be recollected, that the simplicity and equable motion of the machinery, and the perfect uniformity of the work to be performed, precludes almost entirely the possibility of derangement. Wind and tide, rough and smooth water, light or darkness, would have no influence whatever over steam-carriages moving on these ways.

It cannot be denied, then, that these circumstances must render the travel on these railways *very convenient.* But it is not the certainty alone, but the celerity and dispatch of this mode of traveling, which gives it so decided a preference to navigating on a canal, and, indeed, to every other mode of conveyance. The farmer who carries his produce to market,

will, by means of this mode of conveyance, save three days out of four. And by means of it, also, the traveler will in one day perform more than a week's journey on a canal.

But "many accidents would happen by carriages running against each other, in cases of accidental or necessary stops." There are easy and obvious modes of effectually guarding against all accidents of this sort. In the first place, deposits of wood and water must be formed every ten or twelve miles; and each suit of carriages must make no regular halt, except at those places. As to accidental stops, these, for the reasons assigned above, will very rarely or never happen. The stopping places must, of course, be always on level ground. And it must be an invariable and established rule, that *all* the carriages which stop at one time and place be firmly connected to each other.

Whilst these regulations are strictly observed, no accidents of this sort can ever happen. The conductor of each suit of carriages is precisely acquainted with the position of every stopping place, and governs himself accordingly. He takes care to bring too in time, so as not to run against other carriages; and should it be necessary (although I am inclined to think it will not), means might readily be taken to bring too more expeditiously. For the accommodation of carriages for carrying passengers, it will be very practicable and easy to contrive, at each of these stopping places, a mode of turning out on the adjoining ways, so as to admit of their passing the carriages for the transport of heavy articles.

"But the means of stopping these heavy carriages, without a great shock, would be very difficult." It is very surprising that you should apprehend the least difficulty about a thing so easy to effect. On stopping the engine, the friction of the wheels, turning on their axis, will gradually retard the motion of the whole suit of carriages (the friction operating

uniformly at the axis of each wheel), till at length they will all, almost imperceptibly, become stationary, without the possibility of producing anything like a *shock*.

"The carriage of condensing water would be very troublesome." I am persuaded you would never have advanced this objection, had you adverted to the circumstance of my stating expressly in the memoir, that the engine was to be wrought by the elasticity of the steam merely.

I have now fully, and, as I conceive, satisfactorily answered every objection you have urged, and, of course, they have only served to establish more firmly in my mind the very favorable sentiments I entertain respecting the practical utility of the proposed railways.—Yours, &c.

JOHN STEVENS.

Addressed to Gouverneur Morris, Esq., Chairman to the Board of Commissioners for Inland Navigation.

NO. 6.

The following is a copy of a letter addressed to Gouverneur Morris, Esq., Chairman to the Commissioners for the improvement of Inland Navigation.

NEW-YORK, *March* 11, 1812.

Sir—I lately enclosed, in a letter directed to De Witt Clinton, Esq., a memoir addressed to the Commissioners, which no doubt, he has communicated to the Board. In this memoir I have endeavored to prove, and I hope not unsatisfactorily, the great superiority of the proposed railways, to canals. The only question then is, whether steam engines can, without much difficulty be applied to the purpose of propelling carriages. To the expression of an opinion on this matter, I certainly have some pretensions to competency. After having then maturely considered the subject, I am firmly convinced that steam engines can be applied to propelling carriages on these rail-ways, with much more facility

than they are now made use of for propelling boats. The machinery of a steam engine requisite for propelling carriages may be simplified greatly. Cog-wheels, air-pumps, condensing apparatus, plug frame, and fly-wheels can all be dispensed with. Of course then, the liability of the machinery to derangement will be proportionably diminished. But to place this matter beyond all possibility of doubt, let it be subjected to the infallible test of actual experiment. As has already been stated in my letter to Mr. Clinton, "an experiment sufficiently extensive to ascertain unquestionably the real merits or demerits of this proposed plan could be tried at the expense of two or three thousand dollars." It remains then for the Commissioners to determine whether the advantages which this plan promises, afford sufficient inducements to authorize them to recommend an appropriation of a moderate sum, to be applied to the making the necessary experiments. I now pledge myself that the expense of these experiments shall not exceed $3,000.

I am aware how unnecessary it would be to attempt to point out to you the magnitude and importance of the consequences which must necessarily result from these railways and steam carriages coming into general use. The communications between the extremes of this extensive empire would be rendered beyond all conception rapid, and, at all seasons, and in all weathers, invariably certain. What influence these circumstances would have on the moral, political, and intellectual attainments of the citizens of these States, cannot now be duly appreciated; but unquestionably their permanent prosperity and happiness, as well as temporary ease and comfort, would be greatly promoted.

Should any objections occur, either to yourself, or any of the rest of the members of your Board, against the plan I have submitted to their consideration, you will confer a particular

favor by stating them to me. Pardon the trouble which my solicitude on this subject occasions. I must confess, that having been somewhat instrumental in the introduction of the art of propelling boats by means of steam, I feel ambitious of the honor of introducing the application of the same agent to propelling carriages. And as *steam-boats* have been first brought into practical use on the waters of the Hudson, so I hope and trust that it will not be long before the abundant products of our interior will be conveyed to the banks of this noble river by means of *steam-carriages.*

I am, Sir,

Yours, &c.,

JOHN STEVENS.

NO. 7.

The following is a copy of a Letter from Mr. G. Morris.

ALBANY, *March* 16, 1812.

Sir—I am directed by the Board of Commissioners to transmit the enclosed copy of a report made by the Committee to which your letter was referred. I avail myself of the opportunity to present the assurances of that respect with which I have the honor to be,

Sir, your obedient servant,

GOUVERNEUR MORRIS.

NO. 8.

Copy of the Report of the Committee.

The Committee to whom was referred the Communication from John Stevens, Esq., recommending the construction of a Wooden Railway,

REPORT,

That they have considered the said communication, with

the attention due to a gentleman whose scientific researches and knowledge of mechanical powers entitle his opinions to great respect, and are sorry not to concur in them.

Mr. Stevens proposes a railway on which a steam engine is to propel, by a force equal to the competent number of horses, one hundred tons at the rate of four miles an hour.

As horses move on the earth, when drawing a weight, it is believed that an equal power must, to produce the same effect, have sufficient hold on the earth; and it is doubted whether an engine in a wagon can work it forward with as much advantage as horses on a road.

If the engine turn the wheels, and propel the weight by their friction on the railways, it may be questioned whether the effect will equal expectation.

The rims of the wheels (however acurate), will, it is apprehended, impede (by their friction) the progressive motion. Such at least would be the case were the wagon drawn by horses.

Friction must be increased, if the logs of the railway should warp. And it may be doubted whether workmen could be found of sufficient skill (even could they have a choice of seasoned timber) to prevent the warping of logs by change of weather from hot to cold and from wet to dry.

If the rims and railway should not fit exactly, there might result such variance of direction, as would bring the rims to cut the rails. But if the wheels fit exactly when the logs are green or wet, they can do so no longer when those logs become seasoned and dry. If, on the contrary, the railway should be constructed of dry or seasoned stuff, wheels when well fitted to it would, when rain or damp air had swollen the rails, be squeezed along with difficulty.

Supposing, nevertheless, that non-elastic, incompressible railways were so constructed as not to warp, the slightest

failure of foundation on either side would give a bias which (to use a workman's phrase), throwing it out of truth, might occasion its destruction by lateral pressure.

But the result just mentioned would be produced unless foundations are laid below the power of frost, and of materials sufficiently solid to bear the great incumbent pressure proposed in the shock of rapid motion.

And thus we are definitely led to ask whether a railway can be constructed of sufficient strength. It is proposed that one hundred tons be put in motion on it, at the rate of four miles per hour, which is nearly two yards in a second. If this motion were produced by force fixed to the earth it must not only be equal to the weight multiplied into the velocity, but as much greater as would be needful to overcome the resistance of friction. No formula has yet been discovered by which to calculate the proportion between power, friction and effect, but experience has demonstrated, that friction is always a deduction from power. When that operates (as is supposed to be intended on the present occasion) by friction at the circumference of wheels, overcoming that which is at their axis (and propelling so great a weight) the deduction must be greater than in common cases. Put it however, for the present at nothing, and for the weight of wagon, steam engine, and fuel allow nothing: still we shall have force 100, and weight 100 (together 200,) working with a velocity of four miles per hour by friction on a railway. It does not seem probable that a way could be made of sufficient strength.

But, if it can, the Committee conceive that it must be composed of materials much more solid and durable than wood. Moreover, as it is self-evident that the same way will not serve for carriages going and returning, the expense which would (it is conceived) for a single way exceed that of a

Canal must be doubled, and would therefore render the construction unadvisable, were it sanctioned by experience."

A true copy from the minutes.

JOHN L. MORTON,
Secretary to the Canal Commissioners.

NO. 9.

Answer to the Report of the Committee.

The objections urged against the proposed railways in the above report of the Committee, appear to me so void of real foundation, that I am constrained to repeat again the sentiment I have already expressed in my answer to the objections brought forward by Mr. Livingston.

These objections "have only served to establish more firmly in my mind the very favorable sentiments I entertain respecting the practical utility of the proposed railways."

The respect, however, due to the gentlemen who constituted this Committee, prompts me to give the following answer.

It is an established principle, resulting from the laws of motion, that all bodies are indifferent to a state of motion or rest. When, therefore, by any means, a determinate velocity is given to a body, that body would continue to move *ad infinitum*, with the velocity originally impressed upon it, were it not resisted by some other force or power. Thus, were we to suppose a sphere or cylinder, perfectly hard and smooth, to be set in motion upon a horizontal plain, also perfectly smooth and hard, it would revolve round the earth forever, were it not impeded by the resistance of the atmosphere. Gravity, in this case, would have no tendency either to retard or accelerate its motion, as the action of gravity would always be exerted in a direction perpendicular to the line of motion. But a railway cannot, in practice, be constructed of materials perfectly hard and smooth; and, although friction rollers in the

hubs of the wheels would take off from the axis a large share of friction, yet still there would remain a considerable quantity to be overcome: what this would amount to in practice, cannot theoretically be precisely ascertained. However, the fact of one horse drawing on a railway upwards of fifty tons for several miles, furnishes sufficient data to calculate upon. We may certainly, with great safety, estimate a steam engine of a two horse power adequate to the purpose of giving motion to one hundred tons weight, on a horizontal railway. But it is proposed to give to this railway, where necessary, an ascent of one degree. On these occasions, then, there will be required a power equal to somewhat more than one sixtieth part of the whole weight of one hundred tons; we will call it three thousand five hundred pounds. This added to the two horse power, necessary to overcome friction, &c., on a horizontal plain, would make a sum total of four thousand pounds. But I have stated already the power of the steam engine at five thousand pounds. But Mr. Latrobe has estimated that "by-the aid of a railway, one horse would transport eight tons, supposing the angle of ascent not to exceed one degree." One hundred tons, then, would require twelve and a half horses, allowing two hundred and fifty pounds for each horse: the power of twelve and a half horses would equal only three thousand one hundred and twenty-five pounds, instead of four thousand, as above estimated.

But when it is considered that more than nineteen twentieths of the whole distance will be nearly on a horizontal level, which would require no more than a two or three horse power, instead of twenty, at which the engine is estimated, we surely need not apprehend a deficiency of power. But "as horses move on the earth when drawing a weight, it is believed that an equal power must, to produce the same effect, have sufficient hold on the earth: and it is doubted

whether an engine in a wagon can work it forward with as much advantage as horses on a road."

I must confess I cannot see the force of this objection; and fearful that it might contain something which had escaped my attention, I submitted it to a number of scientific gentlemen, who unanimously concur with me, that, provided the wheels do not slip on the ways, the whole power of the engine is exerted to the best advantage in propelling the carriage forward. There will, no doubt, in proportion as the shackle pin approaches to, or recedes from, the periphery of the wheel, be a difference in the relative velocity of the carriage and the piston; whereas, the horse and the carriage always move forward with the same velocity.

"If the engine turn the wheels, and propel the weight by their friction on the railway, it may be questioned whether the effect will equal expectation."

No *friction* (except at the hubs) results from the revolutions of the wheels on the railways. *Resistance* will, however, occur, in proportion to the frequency and magnitude of the elevations and depressions of the railways, and their deviations from a horizontal plain.

"The rims of the wheels, however accurate, will, it is apprehended, impede by their friction the progressive motion. Such at least would be the case, were the wagon drawn by horses."

It has just now been stated, that no friction whatever takes place at the rims of the wheels of a carriage on a railway. This would invariably be the case whether the carriage were propelled by horses or by a steam engine.

But the timber of these railways would be liable to warp: I would propose to construct the ways of white pine, twelve inches deep and six wide at bottom, reduced to four at top, and of as great a length as can conveniently be had: say fifty

or sixty feet. Now, if the supports are thirteen feet apart, these pieces will rest on them in five or six different places, where they can be confined immoveably. Under such circumstances it is not possible they should warp. As pine, although sufficiently strong to support the weight of the carriages, would be too soft for the rims of the wheels to run on, cap-pieces of oak, two inches thick and four inches wide, must be fastened on the top of the rails.

But these rails will be liable to shrink and swell with "the changes of the weather, from hot to cold, and from wet to dry." From the observations I have made on this subject, the greatest variations of dimension in a piece of timber of four inches wide, does not, from the joint operations of these causes, exceed the eighth of an inch; but were it even half an inch, the effects apprehended by the Committee could never occur. The extremities of the rims of the wheels should be about two inches deep, and curving outwards in such a manner as merely to squeeze the rail when on any variation of direction, the projections of the rims should be made to come in contact with each side of the rails. As, however, the wheels to which the shackle pins are fixed, are wedged fast to each end of an axis revolving with them, they are necessarily prevented from deviating from the line of draught. And, as the carriages which are drawn behind are firmly attached to each other, they must all pursue one course.

For this reason, I still continue decidedly of opinion that wooden railways will answer well in practice, and be but little subject to wear. But should experience hereafter prove the fallacy of the ideas I now entertain respecting wooden railways, recourse could at any time be had to iron. Not one shilling of unnecessary expense would be incurred. The iron, whether wrought or cast, could be fastened on the top of the wooden rails, and the business would be done. All the

objections which have been urged against wood, as an unfit material, would thus be completely obviated.

But it would be essentially necessary that "foundations be laid below the power of frost, and of materials sufficiently solid." And should it also be found necessary that the wheels should be made to run on iron, the Committee give it as their opinion that the expense would exceed more than double that of a canal.

In support of this assertion they exhibit no proofs, they advance no calculations. The Commissioners themselves acknowledge that, with respect to a canal, it "would be unpardonably presumptious should they pretend to acuracy of calculation." The truth is, as I have elsewhere observed, that any estimation of the cost of a canal, such as is contemplated, must, from the nature of the business, be in a great measure conjectural. In their former report they have stated it at five millions, and in their late report, they sum up the whole expense at six millions of dollars. Nine tenths, or, perhaps ninety-nine one hundredths of this expense will be incurred for labor bestowed principally in excavating ground at present unexplored. Without taking into calculation, then, the great want of economy and gross abuses which ever attend all public works, there is every reason to believe that were the estimate of the Commissioners doubled, it would fall far short of the ultimate cost of the proposed canal. But as has been already well observed in the report of the Commissioners, the magnitude of the expense is not an object of the first moment. Were a canal to cost ten times as much as the proposed railways, if decidedly preferable, the difference of expense should by no means prevent it being carried into effect. And so, on the contrary, should the railways be found most convenient and eligible, the difference in expense ought not to be regarded.

I shall now proceed to a minute calculation of the cost of

railways executed in the most solid and permanent manner. Such, however, is the nature of the work, that the far greater part of it is susceptible of being calculated with a great degree of precision and accuracy.

It will be necessary to reduce the angle of elevation throughout the whole course of the railways so as no part of it shall exceed one degree. To effect this, the hills must be reduced by cuttings, and the valleys raised by mounds. But the expense of these operations will be, in no comparison, as great as would be required for a canal. As the course of a canal must be level, or very nearly so, the depth of the cuttings and the elevation of the mounds must be in proportion. The Commissioners have estimated the expenditure for "aqueducts, embankments, and mounds," at one million of dollars. But as they have estimated the cost of a mound over the Cayuga Lake at nearly one half of this sum, there would remain then about half a million to be applied to these purposes. But for railways no aqueducts are required, and as a variation of one degree from a horizontal line admits of elevations and depressions of upwards of ninety-two feet in a mile, it perhaps might be practicable to carry the railway through from Albany to Lake Erie, with scarcely any occasion for the removal of the earth. For the reduction, then, of elevations, and the erection of necessary bridges, $250,000 appear more than sufficient; but to silence all cavil, we will put it at half a million.

I have met with no person yet, the least conversant with the subject, who entertains the smallest doubt about the strength of wooden supports. Wood, it must be conceded, falls far short of stone or brick in respect of durability. But, as I have already stated, it may still be the most economical material. Athough, then, I can see no valid objection against the use of wood, I will, merely to satisfy the gentlemen of

the Committee, substitute stone or brick in the following estimate.

It may be urged that extensive tracts in the course of the railways are destitute of stone proper for the purpose, and that clay for the making bricks cannot be found everywhere. It will not, I presume, be contested, that in a distance of three hundred miles through a country no section of which, except from Albany to Schenectady, is sandy, a number of places will be found affording good building stone, and good clay for making bricks. By commencing the railways in the vicinity of such places, stone and brick could be transported to wherever these articles may be wanted, at a trifling expense. I have stated the actual expense of transportation at fifty cents per ton for three hundred miles. Supposing, then, that some parts of the way may require a transportation of materials a distance of twenty miles, this, at the above rate, would amount to three and a third cents per ton. But, to avoid all dispute, let the average amount of expense of transportation of materials be estimated at twelve and a half cents per ton. We will, in the first instance, suppose the pillars are composed of brick, six feet high, and eighteen inches square. Each pillar will contain about two hundred bricks. In every thirteen feet of the railway three pillars will be required, or six hundred bricks.

600 bricks, at $3 per 1000, is . . .	$1 80
6-10ths of a days' work of a mason, .	75
Do. of a laborer, .	60
Lime, ...	50
Digging, &c., ...	35
	$4 00

for every thirteen feet of railway, or $20 a chain, =$1600 per mile. Should stone be used, we may add fifty per cent,

or $2400 per mile. Estimating timber at twelve and a half cents a foot, which is certainly more than double what it may be got for, the timber for the ways and the carpenters' work would come to about $1500 per mile. There cannot be a doubt that wrought iron is, on various accounts, preferable to cast iron for the wheels to run on, provided it is of sufficient thickness. I would propose, then, to take, for this purpose, bar iron of half an inch thick and four inches broad. This may be had, at retail price, at six cents per pound; but certainly at much less by the larger quantity. It takes about four cubic inches of wrought iron to make a pound; each inch, then, of these bars will weigh half a pound, and four of them will weigh two pound per inch, or twenty-four pound per foot, at six cents per pound =144 cents per foot, or $7603 per mile.

Bar iron plates, ...	$7603	
Brick pillars, ...	1600	
Timber ways, ...	1500	
	$10,703	
Or, ...		$3,210,900
for the whole distance of three hundred miles.		
For reducing elevation, &c., ...		500,000
Total,		$3,710,000

Should stone, however, be used, the expense will be enhanced $800 per mile, or $240,000 for the whole distance; making a sum total of $3,950,000.

Thus, then, executed in the most durable manner with stone or brick pillars and iron ways, this great undertaking could be completed for a sum certainly not exceeding four millions of dollars.

The only article of expenditure in the foregoing estimate liable to uncertainty is the reduction of elevations of the ground throughout the course of the railways, so as not to exceed one degree. But the Commissioners must have erred very widely from the truth in that part of their estimate relative to the reducing hills, and raising vallies to a horizontal plain, or nearly so, or the sum assigned to the foregoing object must be more than sufficient. The shortest distance between Albany and Lake Erie is two hundred and eighty miles, whereas the Commissioners, in their late report, have conceived it necessary, in order to preserve the requisite levels, to extend the route of the canal, in a circuitous course, to three hundred and fifty miles. With a rise and fall of ninety-two feet in a mile, it will by no means be necessary for the railways to make so extensive a circuit. It probably will be practicable to conduct these ways by a route not exceeding three hundred miles. This will not only be a saving in the expense of construction, but—what will be much more important—it will effect a great saving in the time and expense of transportation.

I have now answered, and, I expect, satisfactorily, every objection made by the Committee. These objections are aimed principally against the use of wood. As iron, stone, or brick, are now substituted, they, of course, become inapplicable. And as the doubt the Commissioners expressed—"whether an engine in a wagon can work it forward with as much advantage as horses on a road"—has not the least foundation, the only objection then remaining is, that the expense of railways would be more than double that of a canal. But if the above estimate is not very erroneous, the railways will not cost one-half as much as a canal. But as the Commissioners in their late report have abandoned the idea of taking the waters of Lake Erie in an inclined plane to the

Hudson, a never-failing supply of water will be required at the summit level or levels. It is a notorious fact that tracts of country become more or less arid as they become cleared of timber. Whether, then, a sufficient supply of water will at all times be commanded when the country through which the canal has to pass becomes fully populated, is a very serious and important question. Besides canals are liable to innumerable casualties. Sudden torrents frequently produce incalculable mischief. It is often extremely difficult to prevent and stop effectually leaks in a loose porous soil. The frosts in winter and droughts in summer will occasion cracks in the clay. Vermin of various descriptions are perpetually perforating holes. Weeds are ever very troublesome and difficult to eradicate. Their roots are constantly penetrating into the loose earth, and occasioning leaks. The locks are perpetually requiring repairs. Whereas, I know of no casualties to which railways, constructed as now proposed, are liable. Whilst the materials last they must ever remain unaffected by anything short of an earthquake. When it is considered, too, that the travel on these ways remains always, winter and summer, uninterrupted—that there are no locks or other circumstances to occasion delay, that the expense of transportation would not be more than one-third of that on a canal, and the original expense of construction not more than one-half—when, I say, all these things are taken into consideration, how can we hesitate to give a preference to the railways?

But, notwithstanding the many inconveniences I have enumerated, the great utility of canals is "sanctioned by experience;" whereas the practical utility of railways on the proposed construction, remains yet to be ascertained by actual experiment.

But when millions are to be expended, shall a few thou-

sand dollars be grudged to make the experiment on an object promising so fairly ?

But it wonld be useless to pursue the subject farther. Should what has been already said be insufficient to open the eyes of the Committee, I have only to lament that their blindness on this occasion will certainly be followed by a future regret. A discovery, more especially a physical one, when once made, and its developement fairly exhibited before the public, can never, if of any importance, be lost or suppressed. Sooner or later then, the improvement now proposed will be brought into general use, and, if I mistake not, long before the projected canal will be completed.

It will obviously occur that a number of passages contained in the report of the Committee are not particularly noticed. If, for instance, no particular notice is taken of the following passages, viz.: "If this motion were produced by force fixed to the earth, it must not only be equal to the weight multiplied into the velocity"—again—"No formula has yet been discovered by which to calculate the proportion between power, friction, and effect"—"Still we shall have force 100, and weight 100 (together 200), working with a velocity of four miles per hour by friction on a railway," if these and some other passages are not particularly noticed, yet a due attention to what has been advanced in the above reply to the Committee's objections, will satisfy every impartial reader that they have been *all* substantially answered.